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(54) Title: AGGLOMERATED POLYURETHANE FOAM AND METHOD FOR MAKING THIS FOAM

(57) Abstract

An agglomerated polyurethane foam consisting mainly of soft polyurethane foam particles bonded to one another by means of glue, and which have a minimally damaged cell structure like the structure which can be obtained by cutting pieces of said soft polyurethane foam and are bonded to one another by means of said glue in such a manner that the agglomerated polyurethane foam has a density comprised between 15 and 50 kg/m^3, the polyurethane foam particles having before being glued together an average volume comprised between 0.15 and 25 cm^3, and preferably between 0.5 and 5 cm^3.

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"Agglomerated polyurethane foam and method for making this foam."

This invention relates to an agglomerated polyurethane foam consisting mainly of soft polyurethane foam particles bonded to one another by means of glue.

Such agglomerated polyurethane foams are already known in practice. These known agglomerated foams are made of waste produced when cutting gross blocks of polyurethane foam into cushions, mattresses, and the like.

According to the known method, this waste is ground into flakes in so-called flake mills. These flakes are treated with glue and are subsequently compressed into a mould to the desired density. Thereafter, the glue is allowed to cure before demoulding the agglomerated foam.

A drawback of the so obtained agglomerated foams is that they have a relatively high density, usually more than 60 kg/m^3, and hence a much too high hardness to be used as stuffing for sitting furniture or mattresses. In practice, they are therefore utilised in other fields for example as carpet-mats, acoustic foams, packing materials, contour reinforcements of a sitting cushion or a mattress and the like.

The invention has now, however, as object to provide an agglomerated polyurethane foam, which, in contrast to the known agglomerated polyurethane foams, is suitable for being used as stuffing in cushions, mattresses and the like, in other words for the same applications as the basic soft polyurethane foam used

for making the agglomerated polyurethane foam according to the invention.

To this end, said particles have a minimally damaged cell structure like the structure which can be obtained by cutting pieces of said soft polyurethane foam and are bonded to one another by means of said glue in such a manner that the agglomerated polyurethane foam has a density comprised between 15 and 50 kg/m^3, the polyurethane foam particles having before being glued together an average volume comprised between 0.15 and 25 cm^3, and preferably between 0.5 and 5 cm^3.

In contrast with the known agglomerated polyurethane foams, the constituent particles of the foam according to the invention have a minimally damaged cell structure for example because they are obtained by cutting pieces of soft polyurethane foam. Possibly, these particles can also be obtained by other cutting techniques, for example by blanking, sawing and the like provided that also only a minimum damage of the cell structure is caused by these cutting techniques. On the contrary, when grinding soft polyurethane foam into flakes, the cell structure is damaged considerably. Moreover, the so obtained particles of the known agglomerated polyurethane foams have further an irregular geometry showing all kinds of tears, ravels and the like. As a result thereof, the known agglomerated polyurethane foams require a big quantity of glue and the constituent flakes provided with glue have to be compressed in a relatively far-reaching manner to obtain a sufficiently coherent entity. In practice, it is found that a compression up to more than 2.5 times the initial density of the basic foam is required to form a coherent entity, these known foam agglomerates having therefore, as already set forth hereinabove, a too high density and hardness for being used as stuffing for mattresses, cushions and the like.

Surprisingly, the agglomerated polyurethane foams according to the invention have been found, however, to be not only suited for the same applications as the basic foam the component particles are obtained from, but moreover to show still better comfort properties.

In particular these agglomerated foams have been found to have an improved comfort or "sag factor" and resilience for a similar density as the one used in sitting furniture and mattress industry and the hardness loss after fatigue has been found to be smaller. Figure 1 illustrates the difference in the compression curve of a normal polyether foam with a density of 40 kg/m^3 and an agglomerated foam with a similar hardness and density as obtained according to the method described hereinafter. Further, the resilience of these agglomerated foams according to the invention is higher than the resilience of the basic foam.

Preferably, the glue by means of which the particles of the agglomerated foam are bonded to one another is a polyurethane glue whereby the possible later recycling of this foam is simplified to a considerable extent.

The invention further also relates to a method for making such agglomerated polyurethane foams. As in the known method mentioned hereinabove use is made herein as starting material of particles of soft polyurethane foam with a density comprised between 12 and 50 kg/m^3, a polymerisable PU-glue is applied onto these particles, the particles thus provided with glue are compressed, this glue is polymerised with the particles in compressed state and the obtained agglomerated polyurethane foam is brought on atmospheric pressure after this polymerisation is substantially completed. In contrast to the mentioned known method, use is however made in the method according to the

invention as starting material of substantially dust-free polyurethane foam particles with an average volume comprised between 0.15 and 25 cm^3, and preferably between 0.5 and 5 cm^3, which can be obtained by cutting pieces of said soft polyurethane foam and which show a minimum damage of the cell structure. Further, these particles are compressed in such a manner and said glue is applied in such a quantity that the agglomerated polyurethane foam has a density comprised between 15 and 50 kg/m^3, and preferably between 20 and 40 kg/m^3.

Because use is made of substantially dust-free particles with a minimally damaged cell structure and with an average volume comprised within the indicated limits, less glue is required on the one hand and, on the other hand, these particles have to be compressed less strongly to obtain a good adhesion. In this way, an agglomerated foam is obtained in the method according to the invention which, due to its relatively low density, is not only suited for being used for the same applications as the basic foam but which has moreover surprisingly even improved comfort properties.

The polyurethane particles used as starting material in the method according to the invention, can in particular be obtained to this end by cutting said pieces of polyurethane foam or by blanking these particles out of these pieces of polyurethane foam. Rotary cutting knives, the distance between the mutual knives of which being adjustable in function of the desired dimensions of the polyurethane particles, are particularly suitable.

Preferably, the pieces of polyurethane foam are decrusted in advance.

Further particularities and advantages of the invention will become apparent from the following description of some possible embodiments of the agglomerated polyurethane foam according to the

invention and of a method for making this foam. This description is only given by way of example and is clearly not intended to limit the scope of the invention.

The agglomerated polyurethane foam according to the invention consists mainly of soft polyurethane foam particles bonded to one another by means of glue. Before being glued together, the polyurethane particles have an average volume comprised between 0.15 and 25 cm^3, and preferably between 0.5 and 5 cm^3. Essential for the agglomerated foam according to the invention is that these particles are glued together in such a manner that the agglomerated foam has a density comprised between 15 and 50 kg/m^3. As a result thereof, this foam can be used for the same applications as the basic foam the constituent particles of the foam are obtained from. Moreover, the agglomerated foam according to the invention has surprisingly, compared to this basic foam, a number of improved comfort properties including the higher "sag factor", the smaller hardness loss after fatigue and the higher resilience. Essential thereto is further also that the constituent particles of the foam have a minimally damaged cell structure like the structure which can be obtained by cutting pieces of soft polyurethane foam. Before discussing further the improved properties of the agglomerated polyurethane foam, a method for making such a foam according to the invention will first be described hereinafter.

In the method according to the invention use is made as starting material of substantially dust-free particles of soft polyurethane foam with a density comprised between 12 and 50 kg/m^3 and with an average volume comprised between 0.15 and 25 cm^3, and preferably between 0.5 and 5 cm^3. As stated already hereinabove, these particles may show only a minimum damage of the cell structure. Such particles can for example be

obtained by cutting pieces of the basis polyurethane foam. Other cutting techniques by which the cell structure is sufficiently maintained and producing substantially no tears or ravels of the basic foam, such as for example by blanking the particles out of the polyurethane foam pieces, may however also be considered to this end. Possibly, the particles can also be sawn but then care should be taken that the dust and powder of the particles produced thereby is removed for example by providing a suitable suction or blowing device.

Preferably, these techniques are used to make particles with a regular geometry, for example in the shape of cubes, beams, prisms, cylinders etc. However, this geometry has not necessarily to consist of regular bodies, but has to consist of bodies delimited by planes or curves with a clean cutting surface. This is clearly not possible with a flake mill because such a mill produces flakes of irregular shapes, the cell structure of which is moreover considerably damaged. At the same time, the foam is subjected more to fatigue and more dust and powder is further produced.

In the method according to the invention, the pieces of polyurethane foam are for example formed by the waste obtained when cutting gross blocks of basic foam, which are preferably decrusted. Of course, it is to be preferred to decrust the gross block prior to cutting it. The particles obtained from such decrusted pieces of polyurethane foam are thus qualitatively identical to the foam processed into cushions, mattresses and the like.

To adhere the polyurethane particles to one another, they are for example first of all introduced into a mixing tub. Then a polymerisable glue is applied onto these particles, in particular by spraying it over the particles while stirring them by means of a stirring member. After continuing stirring for some time, the

glue is uniformly divided over the surface of the particles.

In the method according to the invention, a relatively small amount of glue is required for bonding the particles to one another, since the cell structure of these particles is minimally damaged and since they are substantially dust-free. A regular geometry, i.e. the absence of tears and ravels, also contributes to a smaller need of glue. In particular, 3 to 20 percent by weight and preferably 5 to 10 percent by weight of glue is applied onto the polyurethane foam particles, calculated on the final weight of the agglomerated polyurethane foam.

Preferably, use is made of a polyurethane glue, more particularly a polyurethane glue on the basis of a prepolymer of TDI and/or MDI with conventional ether polyols, such as used for the production of soft polyurethane foams. Usually, such prepolymers have a free NCO-groups content in percentage comprised between 5 and 25 % and preferably between 5 and 15 % for TDI-prepolymers and between 10 and 20 % for MDI-prepolymers. Such prepolymers have an analogous chemical structure as the foam itself which may be important later for a possible recycling.

After applying the glue over the particles, they are transferred from the mixing tub to a press having usually the shape of a right angled or cylindrical block. Use can also be made of very complex moulds such as for example for making moulded car seat cushions. In these moulds, the particles are compressed in particular in such a manner that the density of the agglomerated polyurethane foam is at least 0.8 times the density of the polyurethane foam from which the particles are obtained, or the average density if these particles are obtained from pieces of foam having different densities. This minimal compression is

important to obtain a homogenous agglomerate with sufficiently good mechanical properties such as tear and tensile strength and also to obtain the advantages as to "sag factor" and hardness loss after fatigue.

The polyurethane foam particles, on the contrary, will normally not be compressed to such an extend that the density of the agglomerated foam would comprise more than 2.5 times the density of the foam from which the particles are obtained. Indeed, should this ratio be higher than 2.5, the hardness of the agglomerated foam becomes too high for replacing the conventional foams in the seating and mattress industry.

After curing of the glue, the agglomerated foam block can be demoulded or in other words can be brought back onto atmospheric pressure. For prepolymers having an excess of NCO-groups, the curing may be accelerated by blowing in for example saturated steam for about 5 min.

In conclusion, it has further to be mentioned that according to this process also post-consumer PU-soft foam wastes can be processed, such as for example from old mattresses and seats provided they are freed from foreign materials such as covering, springs, etc.

A number of examples of the invention are given hereinafter, wherein the improved properties of the agglomerated polyurethane foam according to the invention and therefore also the advantages of the method according to the invention, are clearly shown. To facilitate the comparison between the different agglomerated foams, use is always made in these examples of the same glue and concentration, namely 10 % prepolymer on the basis of TDI with a free NCO percentage of 15. As example four typical basic foams are respectively treated in Tables 1 to 4. The main properties, which are considered in this invention i.e. density, hardness, "sag factor", hardness loss after

fatigue and resilience are compared between the basic foams and the agglomerated foams made therefrom. A cutting machine with three sets of rotative knives was used to produce the foam particles with clean cutting surfaces. In the tables, both the distance between the knives and the corresponding theoretical volume of the particles are indicated. The apparent density of the particles which are loosely piled up to one another is also mentioned as well as the used degree of compression, which is the ratio of the density of the obtained agglomerated foam to the density of the basic foam. Similar densities from different tables should be compared showing that different hardnesses can be achieved by starting from a similar density.

Example

Table Ref.	Column Ref.	Density in kg/m^3	ILD 40 % in Newton
1	2nd	30.5	174
2	3rd	31.8	141
3	2nd	31.6	103
4	3rd	30.6	92

Basic foam : Code T 30180
Adjustment cutting knives : 8 X 8 X 8 mm = 0.51 cm^3 TABLE No. 1
Apparent density in kg/m^3 : 14.9
(of cut foam particles)

Properties	Basic foam	Agglomerated foam		
Density in kg/m^3 (ISO 845)	28.4	30.5	41	
ILD (ISO 2439 B) 25 %	152	118	156	
40 %	188	174	235	
65 %	355	394	569	
Sag factor (65/25)	2.3	3.3	3.6	
Fatigue - Load ponding test (ISO 3385) Hardness loss in % at 40 % compression	33	28	27.4	
Resilience (ASTM D 3574 H)	45	50	53	
Degree of compression = Density agglomerated foam / Density basic foam	--	1.07	1.44	

Basic foam : Code T 22110
Adjustment cutting knives : 8 X 4 X 24 mm = 0.77 cm^3 TABLE No. 2
Apparent density in kg/m^3 : 9.1
(of cut foam particles)

Properties		Basic foam	Agglomerated foam		
Density in kg/m^3 (ISO 845)		19.9	26.6	31.8	40.6
ILD (ISO 2439 B)	25 %	91	73	90	121
	40 %	114	112	141	196
	65 %	218	262	350	551
	Sag factor (65/25)	2.4	3.7	3.9	4.5
Fatigue - Load ponding test (ISO 3385) Hardness loss in % at 40 % compression		42.5	38.1	31	24.5
Resilience (ASTM D 3574 H)		45	50	49	53
Degree of compression = Density agglomerated foam / Density basic foam		--	1.25	1.6	2.04

Basic foam : Code T 30120
Adjustment cutting knives : 10 X 10 X 10 mm = 1 cm^3 TABLE No. 3
Apparent density in kg/m^3 : 15.3
(of cut foam particles)

Properties		Basic foam	Agglomerated foam		
Density in kg/m^3 (ISO 845)		28.1	31.6	44.5	
ILD (ISO 2439 B)	25 %	94	70	97	
	40 %	114	103	149	
	65 %	200	228	370	
	Sag factor (65/25)	2.1	3.3	3.8	
Fatigue - Load ponding test (ISO 3385) Hardness loss in % at 40 % compression		33.7	28.5	22.5	
Resilience (ASTM D 3574 H)		50	52	53	
Degree of compression = Density agglomerated foam / Density basic foam		--	1.12	1.58	

Basic foam : Code T 20070
Adjustment cutting knives : 10 X 10 X 10 mm = 1 cm^3 TABLE No. 4
Apparent density in kg/m^3 : 10
(of cut foam particles)

Properties		Basic foam	Agglomerated foam		
Density in kg/m^3 (ISO 845)		18.3	25	30.6	41.4
ILD (ISO 2439 B)	25 %	60	50	60	78
	40 %	75	74	92	128
	65 %	131	174	223	360
	Sag factor (65/25)	2.2	3.5	3.4	4.6
Fatigue - Load ponding test (ISO 3385) Hardness loss in % at 40 % compression		35.5	35.6	29.3	23.5
Resilience (ASTM D 3574 H)		46	52	51	52
Degree of compression = Density agglomerated foam / Density basic foam		--	1.37	1.67	2.26

CLAIMS

1. An agglomerated polyurethane foam consisting mainly of soft polyurethane foam particles bonded to one another by means of glue, characterised in that said particles have a minimally damaged cell structure like the structure which can be obtained by cutting pieces of said soft polyurethane foam and are bonded to one another by means of said glue in such a manner that the agglomerated polyurethane foam has a density comprised between 15 and 50 kg/m^3, the polyurethane foam particles having before being glued together an average volume comprised between 0.15 and 25 cm^3, and preferably between 0.5 and 5 cm^3.

2. An agglomerated polyurethane foam according to claim 1, characterised in that said glue is a polyurethane glue.

3. An agglomerated polyurethane foam according to claim 1 or 2, characterised in that it has a density comprised between 20 and 40 kg/m^3.

4. An agglomerated polyurethane foam according to any one of the claims 1 to 3, characterised in that said particles show a substantially regular geometry delimited by planes or curves with a substantially clean cutting surface.

5. A method for making agglomerated polyurethane foam according to any one of the claims 1 to 3, in which method use is made as starting material of particles of soft polyurethane foam with a density comprised between 12 and 50 kg/m^3, a polymerisable glue is applied onto these particles, the particles thus provided with glue are compressed, this glue is polymerised with the particles in compressed state and, after this polymerisation has substantially been completed, the obtained agglomerated polyurethane foam is brought on atmospheric pressure, characterised in that use is made as starting material of substantially

dust-free polyurethane foam particles with an average volume comprised between 0.15 and 25 cm^3, and preferably between 0.5 and 5 cm^3, which can be obtained by cutting pieces of said soft polyurethane foam and which show a minimum damage of the cell structure, these particles being compressed in such a manner and said glue being applied in such a quantity that the agglomerated polyurethane foam has a density comprised between 15 and 50 kg/m^3, and preferably between 20 and 40 kg/m^3.

6. A method according to claim 5, characterised in that said particles are obtained by cutting said pieces of polyurethane foam.

7. A method according to claim 5, characterised in that said particles are blanked out of said pieces of polyurethane foam.

8. A method according to any one of the claims 5 to 7, characterised in that said polyurethane foam particles are compressed in a manner such that the density of the agglomerated polyurethane foam is at least 0.8 times the density of said polyurethane foam pieces and in particular maximum 2.5 times the density of these polyurethane foam pieces.

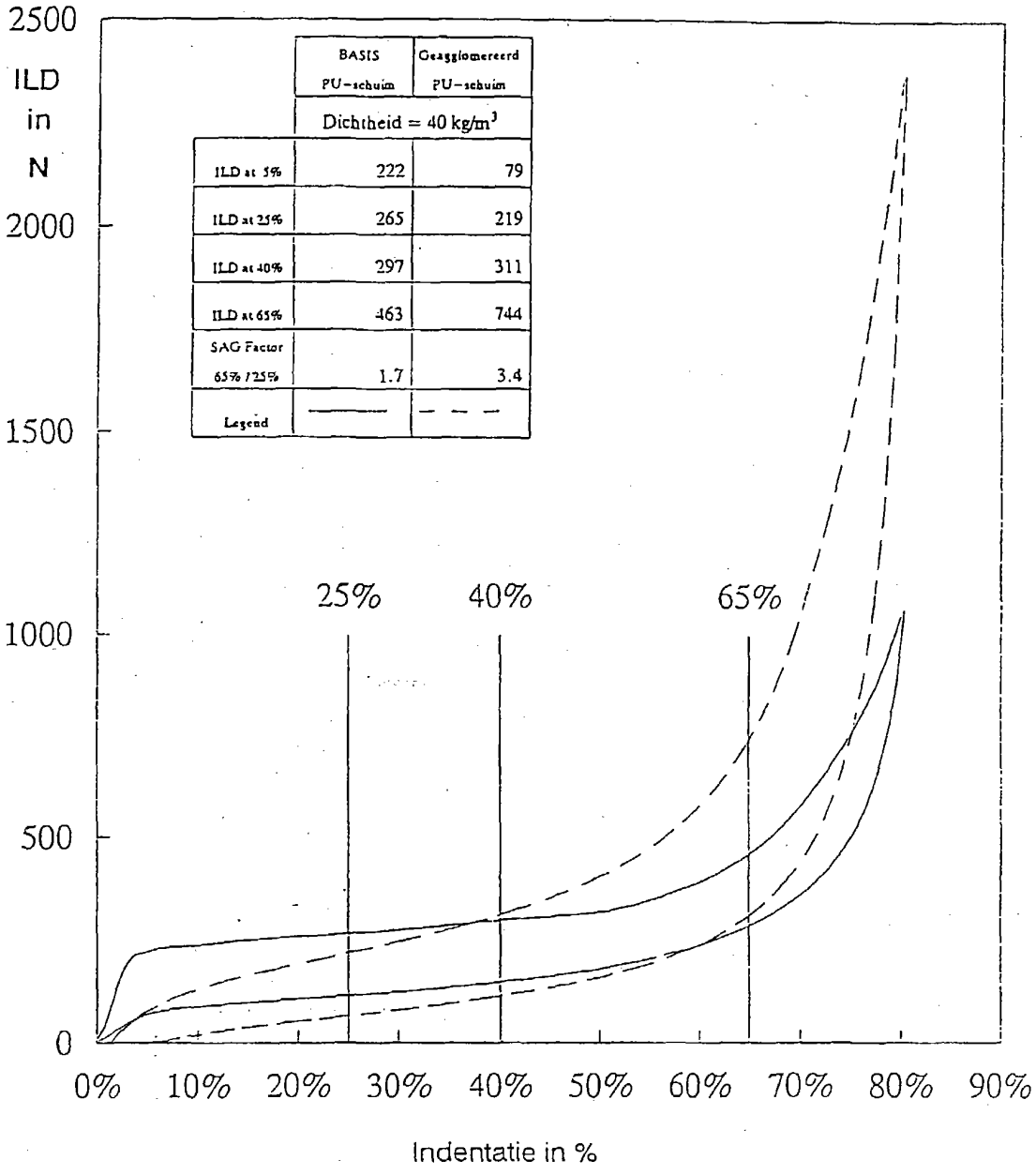
9. A method according to any one of the claims 5 to 8, characterised in that said pieces of polyurethane foam are decrusted in advance.

10. A method according to any one of the claims 5 to 9, characterised in that 3 to 20 percent by weight and preferably 5 to 10 percent by weight glue is applied onto the polyurethane foam particles, calculated on the final weight of the agglomerated polyurethane foam.

11. A method according to any one of the claims 5 to 10, characterised in that said glue is sprayed over the polyurethane foam particles while stirring these latter particles.

12. A method according to any one of the claims 5 to 11, characterised in that use is made of a polyurethane glue, more particularly on the basis of a prepolymer of TDI and/or MDI with ether polyols used for producing soft PU foams.

13. A method according to claim 12, characterised in that the used polyurethane glue is a polyurethane glue determined on the basis of a prepolymer, the percentage free NCO-groups of which is comprised between 5 and 25 %.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Indentatie in %
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65%
BASIS PU-schuim
Geagglomereerd PU-schuim
Dichtheid = 40 kg/m³
ILD at 5% 222 79
ILD at 25% 265 219
ILD at 40% 297 311
ILD at 65% 463 744
SAG Factor 65% /25% 1.7 3.4
Legend

INTERNATIONAL SEARCH REPORT

In ational Application No
PCT/BE 94/00088

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C08J9/33 C08J9/35 //C08L75:04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C08J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB,A,1 029 961 (DUNLOP) 18 May 1966 see page 2, line 55 - line 96; example 1 see claims 1-13	1-13
A	GB,A,934 345 (KAY BROTHERS LTD.) 12 August 1963 see page 1, line 85 - line 90 see page 2, line 14 - line 23 see claims 1-5	1-13
A	FR,A,1 241 750 (DUNLOP) 16 August 1960 see page 2, line 24 - line 36 see page 3; example 2 see claims 1-4	1-13
A		13

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
2 March 1995	21. 03. 95

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

In. ational Application No
PCT/BE 94/00088

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,4 385 131 (FRACALOSSI & AL) 24 May 1983 see column 7, line 15 - line 40	1-13
A	in het bijzonder, regel 19 - regel 23 see claims 1-6	9
A	DATABASE WPI Week 8226, 19 May 1982 Derwent Publications Ltd., London, GB; AN 82-53120E 'Polyurethane foam chip production.' & JP,A,57 080 032 (OKAZAKI URETHANE KO.) see abstract	1-13

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INTERNATIONAL SEARCH REPORT

Information on patent family members

In. .tional Application No
PCT/BE 94/00088

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
GB-A-1029961		NONE		
GB-A-934345		NONE		
FR-A-1241750	28-12-60	NONE		
US-A-4385131	24-05-83	CA-A-	1176116	16-10-84
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